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ABSTRACT

The objectives of this study were: to investigate biology students' perceptions of the classroom and the laboratory learning environments by means of the Questionnaire on Teacher Interaction (QTI) and the Science Laboratory Environment Inventory (SLEI) instruments and to compare these perceptions with the environments ideally liked or preferred by students; to determine associations between students' cognitive achievement, practical performance and attitudinal outcomes, and students' perceptions of the classroom and laboratory learning environments in biology classes; and to determine the unique and common contributions of the QTI and the SLEI to the variance in biology students' outcomes. While associations between attitudinal outcomes and learning environment dimensions assessed by the SLEI and QTI were stronger than with either achievement or practical outcomes, associations between biology students' perceptions of their learning environment and cognitive and practical performance outcomes reported in this study indicate that certain aspects of the learning environment are associated with students' achievement outcomes. These include the integration of practical and theory work, the degree of open-endedness, the teacher's leadership behavior, and the level of student responsibility and freedom. (Contains 35 references.) (JRH)

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ASSOCIATIONS BETWEEN LEARNING ENVIRONMENTS AND STUDENT OUTCOMES IN BIOLOGY

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OBJECTIVES

This study had three objectives. The first objective was to investigate biology students' perceptions of the classroom and laboratory learning environments by means of two instruments, the *Questionnaire on Teacher Interaction* (QTI) and the *Science Laboratory Environment Inventory* (SLEI), and to compare these perceptions with the environments ideally liked or preferred by students. The second objective was to determine associations between students' cognitive achievement, practical performance and attitudinal outcomes and students' perceptions of the classroom and laboratory learning environments in biology classes. The third objective was to determine the unique and common contributions of the *Questionnaire on Teacher Interaction* (QTI) and the *Science Laboratory Environment Inventory* (SLEI) to the variance in biology students' outcomes.

PERSPECTIVES

International research efforts involving the conceptualization, assessment, and investigation of perceptions of psychosocial aspects of the classroom environment have firmly established classroom environment as a thriving field of study (see reviews by Fraser 1994; Fraser & Walberg, 1991). For example, recent classroom environment research has focussed on constructivist classroom environments (Taylor, Fraser & White, 1994), computer-assisted instruction classrooms (Teh & Fraser, in press) and teacher-student interpersonal behavior in the classroom (Wubbels & Levy, 1993).

Foundations for classroom environment research were laid more than 50 years ago, when the work of Lewin and Murray assumed particular significance. Lewin (1936) introduced the formula $B = f(P,E)$ to describe human behavior (B) as a function of two interdependent influences, the Person (P) and the Environment (E). Murray (1938) developed this theory to describe the concept of the personal needs of an individual (including goals and drives) and the environmental press (including stimulus, treatment and process variables). Murray's needs-press theory led to the development of various measures of personality, but environmental measures rarely were considered in early studies.

In the past 25 years, much attention has been given to the development and use of instruments to assess the qualities of the science classroom learning environment from the perspective of the student (Fraser, 1986, 1994; Fraser & Walberg, 1991), and the association between learning environment variables and student outcomes has provided a particular rationale and focus for the use of learning environment instruments. In a meta-analysis which examined 823 classes in 8 subject areas and representing the perceptions of 17,805 students in 4 nations, Haertel, Walberg & Haertel (1981) found enhanced student achievement in classes which students felt had greater Cohesiveness, Satisfaction and Goal Direction and less Disorganization and Friction. Other literature reviews since then have supported the existence of associations between classroom environment variables and student outcomes (Fraser, 1994).

Walberg's theory of educational productivity (Walberg, 1981, 1984) holds that there are nine factors which contribute to variance in students' cognitive and affective outcomes: student ability, age and motivation; the quality and quantity of instruction, and the psychological climate of the home, the classroom social group, the peer group outside the classroom and the mass media (especially television viewing). Testing of the model using data collected as part of national studies has confirmed its validity in showing that student achievement and attitudes are influenced jointly by a number of factors rather than by one dominant factor (Walberg, 1986; Walberg, Fraser & Welch, 1986). Classroom and school environment factors were found to be particularly important influences on student outcomes, even when a number of other factors were controlled. These findings are consistent with the theoretical model of Getzels and Thelen (1960) which describes the school class as a social system and

suggests that group behavior can be predicted from personality needs, role expectations and classroom environment.

Although past studies have examined associations between student outcomes and student perceptions of the learning environment in science classes (Fraser, 1986, 1994), this study is unique in that, first, it assessed student perceptions of two distinct aspects of learning environments (namely, interpersonal teacher behavior and the laboratory classroom environment) and, second, it examined student outcomes in three distinct areas - student attitude, achievement in a written examination and performance on practical tests.

Previous research has indicated differences in students' perceptions of their actual environment and their ideal or preferred environment (e.g., Fraser, 1991; Levy, Creton & Wubbels, 1993; Wong & Fraser, 1994). Therefore, in keeping with this line of research, differences between biology students' actual and preferred learning environments were explored in this study.

ASSESSMENT OF INTERPERSONAL TEACHER BEHAVIOR

Interpersonal teacher behavior was measured using the *Questionnaire on Teacher Interaction* [QTI] (Wubbels, Brekelmans & Hooymayers, 1991). A two-dimensional model proposed by Leary (1957) formed the basis for the development of the QTI. Teacher behavior is mapped using a Proximity dimension (Cooperation, C – Opposition, O) and an influence dimension (Dominance, D - Submission, S). Each of the items of the QTI is assigned to one of 8 scales: Leadership, Helpful/Friendly, Understanding, Student Responsibility/Freedom, Uncertain, Dissatisfied, Admonishing, and Strict behavior. Typical behaviors for each scale are described in Figure 1. A more detailed description of the model is given in Wubbels, Creton, Levy and Hooymayers (1993) and Wubbels & Levy (1993).

One use of the QTI in The Netherlands involved investigation of relationships between perceptions on the QTI scales and student outcomes (Wubbels, Brekelmans & Hooymayers, 1991). Regarding students' cognitive outcomes, the differences between the various types of teachers could be characterized on the basis that the more that teachers demonstrated strict, leadership, and helpful/friendly behavior, then the higher were the cognitive outcome scores. Conversely, student responsibility and freedom, uncertain and dissatisfied behavior were negatively related to achievement.

In another study, variations in the students' appreciation of the subject and the lessons could be characterized on the basis of the proximity dimension: the more cooperative the behavior displayed, the higher the affective outcomes (Wubbels, Brekelmans & Hooymayers, 1991). That is, student responsibility and freedom, understanding, helpful/friendly and leadership behaviors were related positively to student attitudes. Uncertain, dissatisfied, admonishing and strict behaviors were related negatively to attitudes. Overall, previous studies have indicated that interpersonal teacher behavior is an important aspect of the learning environment which is related consistently to student outcomes.

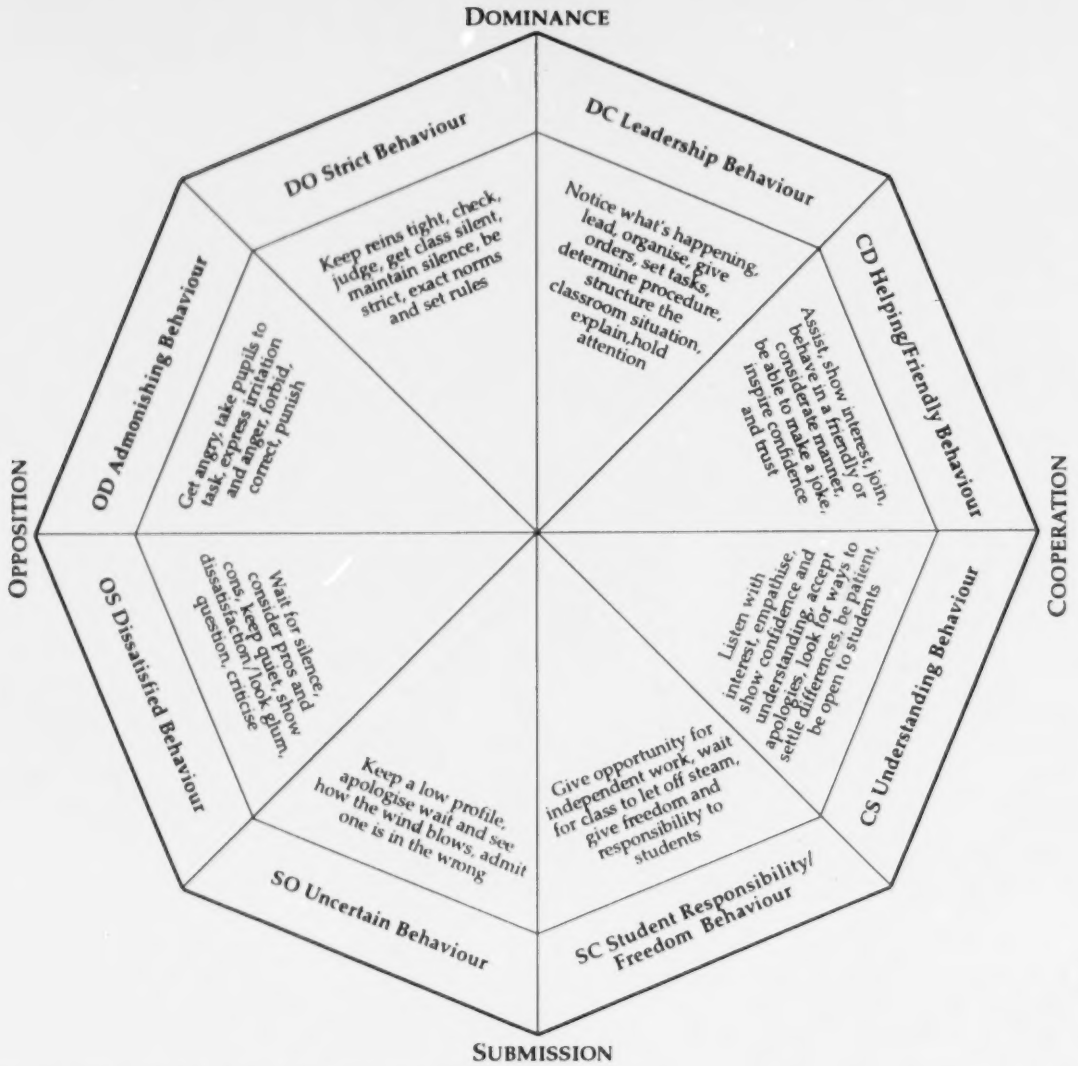
DOMINANCE
DC Leadership Behaviour
CD Helping/Friendly Behaviour
CS Understanding Behaviour
SC Student Responsibility/ Freedom Behaviour
SO Uncertain Behaviour
OS Dissatisfied Behaviour
OD Admonishing Behaviour
DO Strict Behaviour
COOPERATION
SUBMISSION
OPPOSITION
Notice what's happening, lead, organise, give orders, set tasks, determine procedure, structure the classroom situation, explain, hold attention
Assist, show interest, join, behave in a friendly or considerate manner, be able to make a joke, inspire confidence and trust
Listen with interest, empathise, show confidence and understanding, accept apologies, look for ways to settle differences, be patient, be open to students
Give opportunity for independent work, wait for class to let off steam, give freedom and responsibility to students
Keep a low profile, apologise wait and see how the wind blows, admit one is in the wrong
Wait for silence, consider pros and cons, keep quiet, show dissatisfaction, look glum, question, criticise
Get angry, take pupils to task, express irritation and anger, forbid, correct, punish
Keep reins tight, check, judge, get class silent, maintain silence, be strict, exact norms and set rules

Figure 1. The model for interpersonal teacher behavior

ASSESSMENT OF LABORATORY CLASSROOM ENVIRONMENT

Laboratory work is seen as an integral part of most science courses and offers an environment different in many ways from that of the 'traditional' classroom setting. The *Science Laboratory Environment Inventory* [SLEI] (Fraser, McRobbie & Giddings, 1993) was developed to assess student perceptions of the psychosocial environment of science laboratory classes. Each of the 34 items in the SLEI is assigned to one of five scales: Student Cohesiveness, Open-Endedness, Integration, Rule Clarity and Material Environment. The use of these scales provides coverage of the three dimensions identified by Moos (1974) for conceptualizing all human environments.

When applying the three dimensions to the study of learning environments, Moos differentiated Relationship dimensions as measuring the extent to which people help and support one another and the amount of friendship and loyalty within the class, Personal Development (or Goal Orientation) dimensions as indicating opportunities for self-

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enhancement and development of self-esteem. System Maintenance and Change dimensions relate to the extent to which the classroom functions in an orderly, clear and coherent manner and the extent to which innovation is evident. Table 1 shows the classification of each scale of the SLEI according to Moos's scheme and provides descriptive information for each scale.

Table 1. Descriptive information for each scale of the SLEI

Scale Name	Moos Category	Description
Student Cohesiveness	R	Extent to which students know, help and are supportive of one another.
Open-Endedness	P	Extent to which the laboratory activities emphasize an open-ended, divergent approach to experimentation.
Integration	P	Extent to which the laboratory activities are integrated with non-laboratory and theory classes.
Rule Clarity	S	Extent to which behavior in the laboratory is guided by formal rules.
Material Environment	S	Extent to which the laboratory equipment and materials are adequate.

R: Relationship Dimension; P: Personal Development Dimension; S: System Maintenance and System Change Dimension.

DATA SOURCE

The sample was composed of students from 6 of the 8 secondary colleges (Grades 11 and 12) in Tasmania, Australia and two of the independent schools which offer senior biology courses. A total of 489 students in 28 biology classes were involved, representing nearly half of all the students taking biology in 1991. Of the 489 students in the sample, 313 were female, 172 were male and 4 did not indicate their gender.

METHOD

The QTI was used to gauge students' perceptions of interpersonal teacher behavior and the SLEI to gauge students' perception of the laboratory environment. Students completed two forms of the QTI. The first ('actual') form gauged students' perceptions of the teacher whose class the students actually were attending while responding to the questionnaire. The second ('ideal') form asked students to rate the best teacher that had ever taught them. In completing 'actual' and 'preferred' forms of the SLEI, students rated their current laboratory environment and their preferred laboratory environment.

Student attitudes were assessed with an eight-item *Attitude to Science Laboratory Work*, an instrument adapted from the *Test Of Science-Related Attitudes* [TOSRA] (Fraser, 1981) and a seven-item *Attitude To This Class*, which also was based on the TOSRA. Participating students were asked to identify themselves on the questionnaires so that students' scores on different instruments could be matched for analysis purposes.

Each student's performance on the end-of-year examination was used as a measure of cognitive achievement and, because students completed one of two common external examinations, Human Biology or Biology, standardized z scores (i.e., scores expressed in terms of the number of standard deviations above or below the group mean) were calculated to enable meaningful comparison.

In view of the amount of time devoted to practical work in senior biology classes in Tasmania, and the fact that practical work is seen as a distinct mode of instruction involving skills at least in some ways different from those used in non-practical work (e.g. Kelly & Lister, 1969; Tamir, 1991), assessment of students' practical performance was used to provide a third distinctive outcome measure in this study. A subsample of students attempted one or more of a battery of four practical tests based on the Practical Test Assessment Inventory [PTAI] (Tamir, Nussinovitz & Friedler, 1980, 1982) and z scores on these tests were used as a measure of students' practical skills. The present study provides one of the very few uses in which practical performance has been used as an outcome in learning environment research.

Using the scales of the QTI and the SLEI as independent variables, associations were computed with (1) performance on external examination, (2) performance on practical tests, (3) attitude to the class and (4) attitude to laboratory work.

Both simple and multiple correlation analyses were employed, and analyses were performed for both the individual student and the class mean as the unit of analysis.

Commonality analysis was used to determine the degree of common variance shared by the QTI and the SLEI in their contributions to student outcomes, as well as the unique contribution to variance made by each instrument. The purpose of these analyses was to ascertain whether the QTI and the SLEI each accounted for a unique contribution to outcome variance over and above that accounted for by the other instrument. The importance of this aspect of the investigation was to shed light on whether there is any advantage of including **both** the QTI and the SLEI together in the same study in future research.

RELIABILITY AND VALIDITY OF THE INSTRUMENTS

The Questionnaire on Teacher Interaction (QTI)

The reliability and validity of the QTI has been confirmed in prior Dutch, American and Australian studies (e.g. Brekelmans, Wubbels & Creton, 1990; Fisher, Fraser & Wubbels, 1993; Wubbels & Levy, 1991). The use of Cronbach's alpha coefficient in past research has shown that the QTI has an acceptable internal consistency, with figures for student responses ranging from 0.74 to 0.90 (Fisher et al., 1993).

Table 2 reports two reliability and validity statistics for the 48-item version of the QTI used with the present sample of 489 students in 28 biology classes. Consistent with previous research, statistics are reported for two units of analysis, namely, the student's score and the class mean score. As expected, reliabilities for class means are higher than those where the individual student is used as the unit of analysis. Table 2 shows that the alpha reliability figures for different scales in the actual form of the QTI ranged from 0.63 to 0.83 when the individual student is used as the unit of analysis, and from 0.74 to 0.95 when the class mean is used as the unit of analysis. These figures for the 48-item actual version of the QTI are similar to those obtained from a previous study involving Australian students (T. Wubbels, pers. comm.). Table 2 shows that, for the ideal version of the QTI, alpha reliability figures for the different scales range from 0.59 to 0.76 when the individual student is used as the unit of analysis, and from 0.62 to 0.87 when the class mean is used as the unit of analysis. This is the first reported use of the alpha reliability statistic with the 48-item ideal version of the QTI. The values presented provide further cross-validation data supporting the internal

consistency of the QTI, for both actual and ideal versions and with either the individual student or the class mean used as the unit of analysis.

Table 2. Internal consistency (Cronbach alpha coefficient) and ability to differentiate between classrooms for the QTI

Scale	Unit of Analysis	Alpha Reliability		ANOVA Results (eta^2)
		Actual	Ideal	Actual
DC Leadership	Individual	0.83	0.74	0.48*
	Class Mean	0.95	0.76	
CD Helping / Friendly	Individual	0.82	0.76	0.33*
	Class Mean	0.91	0.82	
CS Understanding	Individual	0.78	0.70	0.29*
	Class Mean	0.92	0.87	
SC Student Responsibility/Freedom	Individual	0.66	0.70	0.28*
	Class Mean	0.81	0.67	
SO Uncertain	Individual	0.77	0.66	0.38*
	Class Mean	0.91	0.62	
OS Dissatisfied	Individual	0.75	0.59	0.20*
	Class Mean	0.85	0.76	
OD Admonishing	Individual	0.71	0.72	0.25*
	Class Mean	0.77	0.82	
DO Strict	Individual	0.63	0.69	0.30*
	Class Mean	0.74	0.74	

*$p < 0.001$

The sample consisted of 489 senior biology students in 28 classes.

Another desirable characteristic of any instrument like the QTI is that it is capable of differentiating between the perceptions of students in different classrooms (Fraser, McRobbie & Giddings, 1993). That is, students within the same class should perceive it relatively similarly while mean within-class perceptions should vary from class to class. This characteristic was investigated for each scale of the QTI using one-way ANOVA, with class membership as the main effect. Table 5-1 indicates that each QTI scale differentiated significantly ($p<0.001$) between classes and that the eta^2 statistic, representing the proportion of variance explained by class membership, ranged from 0.20 to 0.48 for different classes. This is the first study to report the use of this statistic with an Australian sample. The figures are generally similar to those reported by Wubbels & Levy (1991) for a sample of schools in the United States.

The Science Laboratory Environment Inventory (SLEI)

Fraser et al. (1993) reported that field testing of the SLEI in six countries (Australia, USA, Canada, England, Israel and Nigeria) confirmed this instrument's reliability and validity. The data presented in Table 3 for the present sample provide further crossvalidation information supporting the reliability and validity of the SLEI, with either the individual student or the class mean used as the unit of analysis.

Table 3. Internal consistency (Cronbach alpha coefficient), discriminant validity (mean correlation with other scales) and ability to differentiate between classrooms for the SLEI

Scale	Unit of Analysis	Alpha Reliability		Mean Correlation with Other Scales		ANOVA Results (eta^2)
		Actual	Preferred	Actual	Preferred	Actual
Student Cohesiveness	Individual	0.81	0.76	0.38	0.43	0.22*
	Class Mean	0.91	0.81	0.52	0.46	
Open-Endedness	Individual	0.58	0.58	0.10	0.17	0.16*
	Class Mean	0.73	0.67	0.18	0.11	
Integration	Individual	0.85	0.76	0.41	0.33	0.17*
	Class Mean	0.92	0.87	0.57	0.46	
Rule Clarity	Individual	0.72	0.62	0.33	0.26	0.18*
	Class Mean	0.88	0.64	0.52	0.40	
Material Environment	Individual	0.77	0.71	0.39	0.40	0.22*
	Class Mean	0.85	0.86	0.52	0.51	

*$p<0.001$
The sample consisted of 489 senior biology students in 28 classes

Table 3 reports three reliability and validity statistics for student responses to the 34-item version of the SLEI used in this study. Statistics relating to the instrument's internal consistency, discriminant validity and ability to differentiate between the perceptions of students in different classrooms are reported for both actual and preferred versions and separately for the individual and class mean as the unit of analysis.

Table 3 shows that, for the actual version of the SLEI, the alpha reliability figures ranged from 0.58 to 0.85 when the individual student was used as the unit of analysis, and from 0.73 to 0.92 when the class mean was used as the unit of analysis. Table 3 shows that alpha reliability figures for the preferred version of the SLEI ranged from 0.58 to 0.76 when the individual student was used as the unit of analysis and from 0.64 to 0.86 when the class mean was used as the unit of analysis. These figures, which are similar to those given by Fraser et al. (1993) for a cross-national sample of students from six countries, further support the internal consistency of both the actual and preferred versions of the SLEI.

The mean correlation of a scale with other scales was used as a convenient measure of the discriminant validity of the SLEI. For the actual version, mean correlations ranged from 0.10 to 0.41 with the individual as the unit of analysis and from 0.18 to 0.57 for class means.

For the preferred version, figures ranged from 0.17 to 0.43 with the student as the unit of analysis and from 0.11 to 0.51 when class means were used. These discriminant validity figures indicate that the SLEI measures distinct (although somewhat overlapping) aspects of the laboratory learning environment, as previously reported by Fraser et al. (1993). Figures obtained in this study are similar to those reported by Fraser et al. when the individual student is used as the unit of analysis, but higher when class means are used.

As previously indicated, it is desirable that classroom environment instruments are able to discriminate between the perceptions of students in different classes. The eta^2 values reported in Table 3 range from 0.16 to 0.22, and indicate that each scale of the SLEI differentiated significantly ($p < 0.001$) between the perceptions of students in different classes.

Attitude Questionnaires

For the present sample, the seven-item *Attitude to This Class* scale was found to have an alpha reliability of 0.68 with the individual student as the unit of analysis and 0.74 when class means were used. Reliability coefficients for the eight-item *Attitude to Science Laboratory Work* were 0.70 and 0.77, respectively, for the two units of analysis.

STUDENTS' PERCEPTIONS OF THEIR ACTUAL AND PREFERRED LEARNING ENVIRONMENTS

Interpersonal teacher behavior

As mentioned previously, each of the 48 items of the QTI is allocated to one of 8 scales, with each scale having 6 items. To enable comparison between students' actual and ideal perceptions of student/teacher interactions, mean scores for each scale were calculated. Because students responded to each item on a five-point scale (from 1-5) and each scale has six items, the maximum score for each scale is 30. These scores are presented in Figure 2.

The data depicted in Figure 2 indicate that, relative to the actual environment currently present, students prefer teachers who show strong leadership, who are more helping and understanding, and who give their students more responsibility and freedom. Students also prefer teachers who are less uncertain, dissatisfied and admonishing. Only in the degree of Strict behaviour shown by their teacher did students' perceptions of their teacher closely resemble the behaviour of their preferred teacher. These results are similar to those reported by Levy et al. (1993) for a sample of Australian students. The disparity between students' actual and ideal perceptions of the level of student responsibility and freedom is similar in scale to that reported by Levy et al. for the Australian sample but greater than that reported (in the same study) for Dutch and American students, suggesting that Australian secondary students prefer more independence than do their Dutch and American counterparts.

The laboratory learning environment

Each of the 34 items in the SLEI is allocated to one of 5 scales, with each scale having 7 items except for Open-Endedness, which has 6 items. Mean scores, calculated for each scale of both actual and preferred versions of the SLEI, are presented in Figure 3. As with the QTI, students responded to items on a five-point scale, so the maximum score for each scale is 35, except for Open-Endedness, for which the maximum score is 30.

The data depicted in Figure 3 clearly indicate that, in comparison with the actual environment, students prefer an environment with higher levels of Student Cohesiveness, Open-Endedness, Integration, Rule Clarity and Material Environment. These results replicate the findings of previous studies using the SLEI (Giddings & Fraser, 1990) and a modified form of the SLEI, the Chemistry Laboratory Environment Inventory [CLEI] (Wong & Fraser, 1994), which showed that students prefer a more positive learning environment with regard to all five scales of the SLEI.

Figure 2. Scale means for actual and ideal versions of the QTI

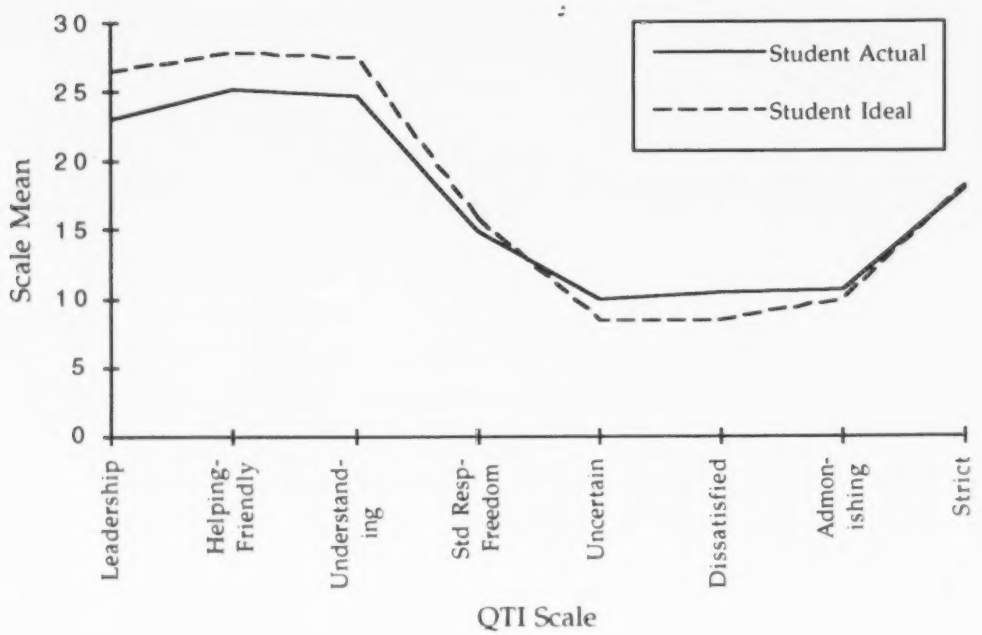
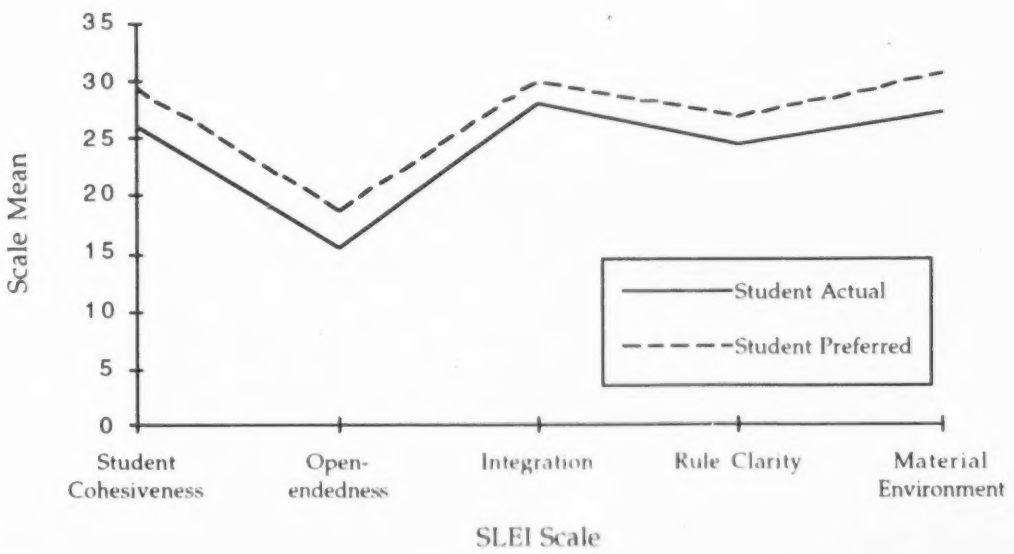


Figure 3. Scale means for actual and preferred versions of the SLEI



ASSOCIATIONS BETWEEN STUDENTS' PERCEPTIONS OF THE CLASSROOM AND LABORATORY LEARNING ENVIRONMENTS AND STUDENT OUTCOMES

In order to investigate associations between students' perceptions of learning environment and students' attitudinal, cognitive and practical performance outcomes, the data were analysed using both simple and multiple correlations. Tables 4 and 5 report these results separately for the QTI and the SLEI, respectively. Whereas the simple correlation (r) describes the bivariate association between an outcome and a QTI scale, the standardized regression weight (b) characterizes the association between an outcome and a particular QTI scale when all other QTI dimensions are controlled.

Table 4. Associations between QTI scales and students' attitudinal, cognitive and practical performance outcomes in terms of simple (r) and multiple (R) correlations

Scale	Strength of Environment–Outcome Association							
	Attitude to Class		Attitude to Laboratory Work		Exam Score		Practical Test Performance	
	r	b	r	b	r	b	r	b
Leadership	0.49**	0.24**	0.40**	0.40**	0.12*	0.24*	-0.06	0.00
Helping/friendly	0.49**	0.21**	0.36**	0.15	0.06	-0.08	0.04	-0.01
Understanding	0.49**	0.11	0.32**	-0.11	0.05	-0.06	0.07	0.22
Student responsibility/freedom	-0.05	-0.07	0.00	0.00	0.10	0.14*	0.19*	0.08
Uncertain	-0.36**	-0.02	-0.20**	0.11	-0.04	0.00	0.13	0.08
Dissatisfied	-0.35**	-0.03	-0.27**	-0.08	0.00	0.02	0.01	0.06
Admonishing	-0.31**	-0.01	-0.23**	-0.03	0.00	0.01	0.00	0.15
Strict	-0.17**	-0.17**	-0.15**	-0.11	-0.03	-0.05	-0.25**	-0.23*
Multiple Correlation, R	0.58**		0.45**		0.19		0.31	
R^2	0.33		0.20		0.04		0.09	

*$p < 0.05$ **$p < 0.01$ n=489

The multiple correlation (R) data reported in Table 4 indicate that associations were strongest between students' perceptions of interpersonal teacher behavior and attitudinal outcomes. Simple correlation (r) figures indicate statistically significant associations between students' attitudinal outcomes and all QTI scales except Student Responsibility/Freedom. The beta weights show that some of these associations, notably those between Leadership and both of the attitudinal outcomes, retain their significance in a more conservative multivariate test with all other QTI scales controlled. In classes where the students perceived greater leadership and helping/friendly behaviors in their teachers, there was a more favorable attitude toward the class and laboratory work. The converse was true when the teacher was perceived as strict. Cognitive achievement was higher where the teachers demonstrated leadership behavior. The only effect on practical performance was that strict teacher behavior correlated negatively with practical test performance.

The data presented in Table 5 show associations between students' perceptions of the laboratory learning environment and attitudinal and achievement outcomes. Examination of the multiple correlation figures reveals a similar pattern to those in Table 4 for the QTI, with associations strongest with attitudinal outcomes, particularly for students' attitude to laboratory work. Simple correlation figures indicate statistically significant associations between attitudinal outcomes and all SLEI scales except Open-endedness. Beta weight values indicate that Integration was the scale most strongly associated with attitudinal outcomes when other SLEI scales are mutually controlled.

Table 5. Associations between SLEI scales and students' attitudinal, cognitive and practical performance outcomes in terms of simple (r) and multiple (R) correlations

Scale	Strength of Environment–Outcome Association							
	Attitude to Class		Attitude to Laboratory Work		Exam Score		Practical Test Performance	
	r	b	r	b	r	b	r	b
Student Cohesiveness	0.20**	0.06	0.31**	0.09	0.01	-0.02	0.02	0.07
Open-Endedness	0.08	0.11*	0.01	0.05	-0.15**	-0.10	0.12	0.14
Integration	0.22**	0.15*	0.42**	0.33*	0.11*	0.14*	0.03	0.12
Rule Clarity	0.22**	0.11	0.29**	0.11*	-0.11*	0.16**	-0.03	-0.06
Material Environment	0.17**	0.06	0.28**	0.01	0.06	0.06	-0.10	-0.18
Multiple Correlation, R	0.29**		0.45**		0.23**		0.20	
R^2	0.08		0.20		0.05		0.04	

*p <0.05 **p < 0.01

UNIQUE AND COMMON CONTRIBUTIONS OF QTI AND SLEI TO VARIANCE IN OUTCOMES

As previously mentioned, this study is the first to use both the QTI and the SLEI with the same sample of students. The use of both instruments would be justified if each were found to make unique contributions to the variance in student outcomes. Therefore, commonality analysis was used to determine the common and unique contributions of each instrument to variance in student outcomes.

Commonality analysis can be illustrated by use of a Venn diagram. Analysis of the contributions of the QTI and SLEI to the variance in one student outcome is shown in Figure 4. In this figure, x represents the unique variance in an outcome attributable to the QTI (beyond that accounted for by the SLEI), y is the unique variance accounted for by the SLEI, and z is the common variance jointly accounted for by the two environment instruments.

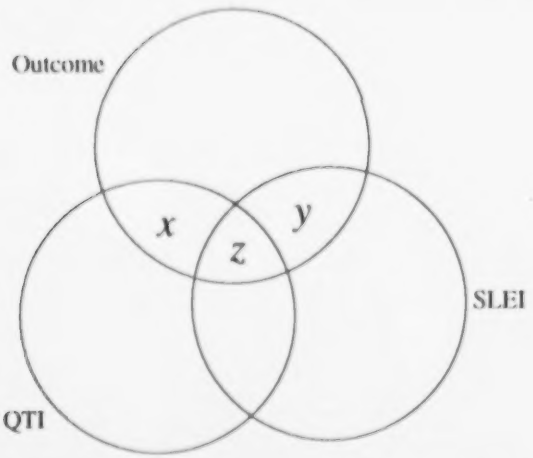


Figure 4. Commonality analysis of the common and unique contributions to outcome variance made by QTI and SLEI

The results of the commonality analysis for each of the four outcomes are given in Table 6. To determine the contributions of the QTI and the SLEI to the variance in attitude to laboratory work, for example, the contribution of the QTI scales (0.20) and of the SLEI scales (0.20) were compared with the total contribution of all scales of the QTI **and** the SLEI (0.29), represented by $x+y+z$. These figures indicate that the unique contribution of the QTI scales is 0.09 ($=x$) and the unique contribution of the SLEI scales also is 0.09 ($=y$). The remaining contribution to variance in student outcomes of 0.11 ($=z$), is common to the QTI and SLEI scales.

Table 6. The unique and common contributions of the QTI and SLEI scales to variance in student outcomes

Variance	Outcome			
	Attitude to Class	Attitude to Laboratory Work	Exam Score	Practical Test Performance
Unique to QTI Scales	0.25	0.09	0.04	0.09
Unique to SLEI Scales	0.00	0.09	0.05	0.04
Common to QTI and SLEI Scales	0.08	0.11	0.00	0.00
Total Contribution to Variance in Outcome	0.33	0.29	0.09	0.13

n= 489

Table 6 indicates that there was a degree of commonality in the contributions of the QTI and SLEI to the variance in students' attitudinal outcomes. Each instrument made a unique contribution to the variance in students' attitude to laboratory work, but only the QTI made a unique contribution to the variance in students' attitude to class. Regarding students' achievement on the external examination and practical test performance, the total contribution of each instrument to the variance in outcomes was unique. Because the QTI and the SLEI each made an appreciable contribution to the variance in students' achievement

outcomes and in attitude to laboratory work which was independent of the variance attributable to the other instrument, it would be worthwhile to use both instruments together in the same study in future research.

CONCLUSION

This study has confirmed the reliability and validity of the SLEI and the QTI. In a general sense, previous research was replicated in that students were found to prefer a more positive learning environment than they perceived to be present. More specifically, the findings from this study are broadly similar to those from previous research involving the QTI or the SLEI in that most of the obvious discrepancies between students' actual and ideal or preferred learning environment apply to the same scales in each instrument.

Whilst associations between attitudinal outcomes and learning environment dimensions assessed by the SLEI and QTI were stronger than with either achievement or practical outcomes, associations between biology students' perceptions of their learning environment and cognitive and practical performance outcomes reported in this study indicate that certain aspects of the learning environment, for example, the integration of practical and theory work, the degree of open-endedness, the teacher's leadership behaviour and the level of student responsibility and freedom, are associated with students' achievement outcomes.

Unique contributions of the SLEI and QTI to variance in achievement were found, although some commonality was found in their contributions to the variance in attitudinal outcomes. Since the QTI and the SLEI each made an appreciable contribution to the variance in achievement outcomes, which was independent of the variance attributable to the other instrument, it is worthwhile using both instruments in future research studies.

This study is distinctive in that it is the first to include student perceptions of interpersonal teacher behavior and student perceptions of the laboratory environment in the one study, and it investigated outcome-environment associations with three categories of student outcomes (attitudes, achievement and practical performance).

This study provides evidence of substantial differences between senior biology students' perceptions of their actual learning environment and the learning environment ideally liked or preferred. Because previous research has indicated that achieving a closer match between students' actual and ideal or preferred learning environments could lead to more favorable student outcomes (Fraser & Fisher, 1983a, 1983b; Fraser, 1994), this study provides biology teachers with information about aspects of the learning environment that, if altered, could lead to increases in students' attitudinal and achievement gains.

This study has indicated that many aspects of teacher interpersonal behaviour and the laboratory learning environment are associated with students' attitudinal outcomes. For example, favorable student attitudes were found to be particularly associated with student's perceptions of the teacher's strong leadership, a greater degree of integration of practical and theory work in the course and a higher level of rule clarity.

Associations between students' perceptions of the learning environment and achievement outcomes reported in this study imply that the teacher's strong leadership, provision of a degree of student responsibility and freedom and integration of practical and theory components of the course are aspects of the learning environment likely to promote favorable achievement outcomes, whilst a greater degree of strict behavior by the teacher, emphasis on rule clarity and an open-ended approach to the course are negatively associated with student achievement.

This results of this study indicate that teacher interpersonal behaviour, as measured by the QTI, and the laboratory learning environment, as measured by the SLEI, are complementary rather than overlapping aspects of the learning environment in terms of their associations with student outcomes. Teachers or researchers using both instruments with their classes will therefore obtain a more complete picture of those aspects of the learning environment likely to promote desirable student outcomes in terms of attitude and achievement.

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